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OLD RIVER OVERBANK STRUCTURE OUTLET MODIFICATIONS: HYDRAULIC MO--ETC(U)
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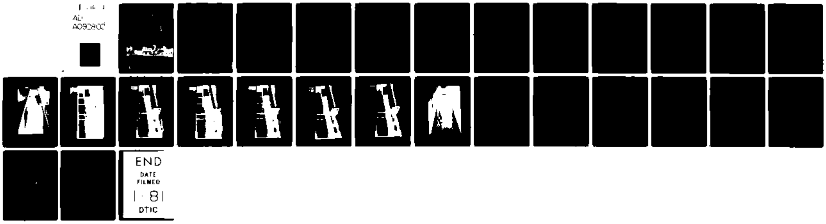

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LEVEL II

MISCELLANEOUS PAPER HL-80-5

OLD RIVER OVERBANK STRUCTURE OUTLET MODIFICATIONS

Hydraulic Model Investigation

by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Six different outlet modification designs for the Old River Overbank Control Structure were evaluated. Model tests were conducted on five of the designs and design variations. A 1:24-scale section model was used to simulate discharges up to 550,000 cfs. Type 5 outlet modification design, utilizing gabions placed parallel to the flow on a 1V on 10H slope, was deemed the best of the six designs tested. Recommendations were also made to increase gabion effectiveness by improved construction and placement methods.

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Preface

The model investigation reported herein was requested and authorized by the U. S. Army Engineer District, New Orleans (LMN), in June 1979. The study was conducted during the period August 1979 to November 1979 in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and under the general supervision of Messrs. J. L. Grace, Jr., Chief of the Hydraulic Structures Division, and N. R. Oswalt, Chief of the Spillways and Channels Branch. The project engineer for the model study was Mr. R. R. Copeland, assisted by Mr. E. L. Jefferson. This report was prepared by Mr. Copeland.

Commander and Director of WES during the conduct of the study and the preparation and publication of this report was COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

Contents

Conversion Factors, U. S. Customary to Metric (SI) Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
inches	0.0254	metres
miles (U.S. statute)	1609.347	metres
pounds (mass)	0.4535924	kilograms

OLD RIVER OVERBANK STRUCTURE OUTLET MODIFICATIONS

Hydraulic Model Investigation

Introduction

1. Model tests of alternative designs for the proposed modification of the Old River Overbank Structure Outlet were conducted at the U. S. Army Engineer Waterways Experiment Station from August through November 1979. The Old River Control Structures are located on the west bank of the Mississippi River approximately 50 miles* northwest of Baton Rouge, La., and approximately 35 miles southwest of Natchez, Miss. (Figure 1). A 1:24-scale section model was used to investigate and compare the hydraulic performance of each of the six different outlet

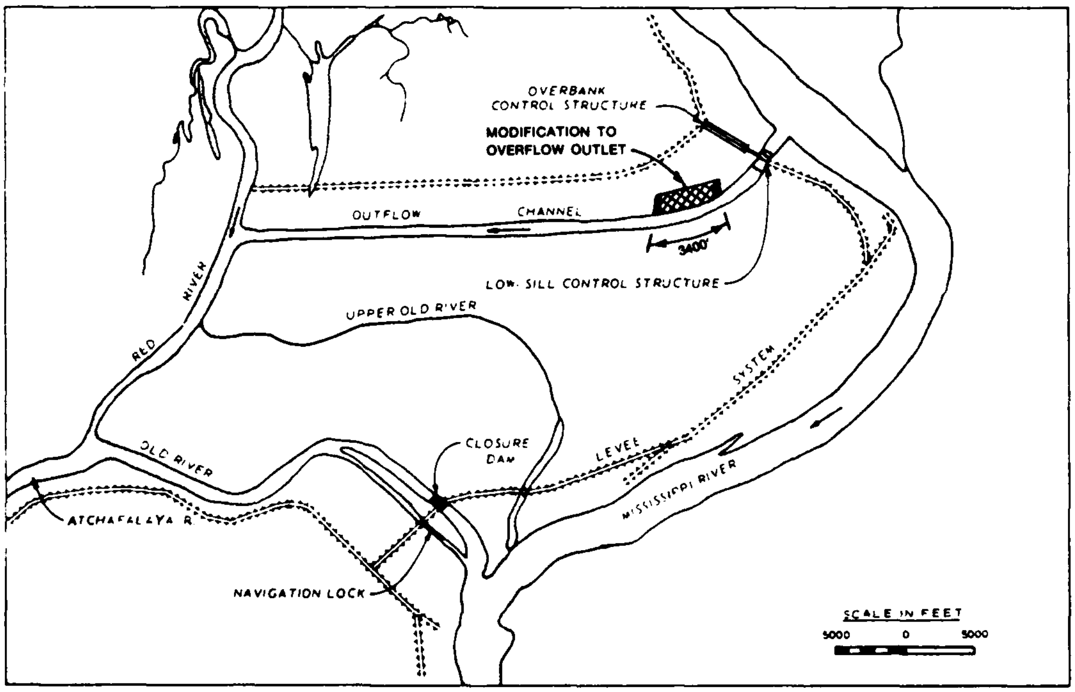

Figure 1. Vicinity map

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

modifications shown in Plates 1-4. This two-dimensional model neglected the effect of crosscurrents and eddies that will occur across the prototype structure and the probable unequal flow distribution on the structure due to the asymmetry of the approach channel.

2. The prototype discharges and tailwaters that were simulated in the section model are tabulated below:

Discharge, cfs	Tailwater Elevation ft msl*
42,000	33.6
78,000	35.7
122,000	37.8
174,000	40.0
230,000	42.2
246,000	45.0
258,000	46.1
320,000	50.7
350,000	36.7
400,000	40.3
450,000	42.9
500,000	45.3
550,000	47.5

The discharge values shown correspond to those over a total structure width of 3400 ft. The section model simulated only a 60-ft width of the proposed uncontrolled spillway. Total discharges of 350,000 cfs and greater would occur only if the Old River Low Sill Control Structure was closed and the entire flow was passed through the Old River Overbank Control Structure. Under such adverse conditions the discharge and tailwater in the Low Sill Outlet Channel would be significantly reduced relative to normal conditions.

Outlet Modification Tests

Type 1

3. The original design (Type 1) outlet modification proposed consisted of a concrete spillway extending from a crest at el 42 down a

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* All elevations (el) cited herein are in feet referred to mean sea level.

1V-on-20H slope to el 35 (Plate 1). The gradation of the proposed upstream and downstream rock riprap is shown in Plate 5. The Type 1 outlet modification contained a hydraulic jump on the concrete slab for only one of the designated test conditions, 320,000 cfs. All other test conditions resulted in failure of the riprap downstream of the slab.

4. Additional tests of the Type 1 outlet modification were conducted to determine the length of the concrete slab necessary for riprap stability. A slab extension of 150 ft down to el 27.6 was found to be satisfactory for discharges of 320,000 cfs and less. The riprap failed for discharges greater than 320,000 cfs. No further concrete slab extensions were tested because the U. S. Army Engineer District, New Orleans (LMN), determined that economic and foundation considerations would eliminate any additional slab extension as a feasible solution.

Type 2

5. The Type 2 outlet modification consisted of a concrete slab from the crest at el 42 down a 1V-on-20H slope to el 35 and gabions between el 35 and el 27.6 (Plate 2). Gabions 12 ft long, 3 ft wide, and 1 ft thick with wire openings of 1.33 in. were simulated in the model. The model gabion baskets were made of standard aluminum screen and filled with crushed rock passing and retained on No. 4 and No. 8 sieves, respectively. The gabions were oriented with their longitudinal axes parallel to the flow. The test indicated that the gabions would be stable; however, the riprap downstream of the gabions failed at discharges greater than 320,000 cfs.

Type 3

6. The Type 3 outlet modification consisted of a gabion spillway extending from 60 ft upstream of the crest at el 42 down a 1V-on-20H slope to el 27.6 (Plate 2). The gabions were oriented with their longitudinal axes parallel to the flow. With discharges at 320,000 cfs and less, a hydraulic jump was satisfactorily contained on the gabion structure. However, discharges between 350,000 cfs and 500,000 cfs caused the riprap downstream of the gabions to fail. The riprap was stable with a discharge of 550,000 cfs and tailwater elevation of 47.5.

Type 4

7. The Type 4 outlet modification (Plate 3) consisted only of riprap and was not tested after it was determined that supercritical flow conditions would occur on the spillway itself, resulting in failure of the riprap with the expected tailwaters. Computations also showed that supercritical flow conditions would exist even if the slope was reduced to 1V on 40H.

Type 5

8. The Type 5 outlet modification as shown in Photo 1 and Plate 4 provides gabion protection on a 1V-on-10H slope from el 42 to el 20. As with Type 2 and Type 3 outlet modifications, the gabions were oriented with their longitudinal axes parallel to the flow. In the prototype, slope protection will be provided by articulated concrete mattresses downstream of the gabion structure. The mattresses were not simulated in the model. This design was stable for all the expected flow conditions, some of which are shown in Photos 2-7.

Type 6

9. The Type 6 outlet modification had the same geometry as Type 5 (Plate 4); however, the gabions were rearranged so that the longitudinal axes were perpendicular to the flow. During initial testing, severe failure of the gabion structure occurred at a discharge of 550,000 cfs as shown in Photo 8. However, this failure did not occur when a second series of tests were run. The failure is attributed to a slight misalignment of the gabions that occurred during placement in the model or by settling of the gabions due to inadequate subsurface drainage and resulting hydrostatic pressure developed during the testing. The same dramatic failure was repeated when one of the gabions was removed manually from the model.

Type 5 with gabion variation

10. The stability of the Type 5 outlet modification was tested under similar conditions. When one gabion was removed, the failure proceeded in a much slower manner and was not as severe. The gabion failure did not proceed upstream as it did with the Type 6 design, and the gabions adjacent to the failure tended to sink into the developing

hole, adding a degree of protection for the rest of the structure. It is noted that the individual size of gabions simulated in the model (12 ft by 3 ft by 1 ft) was smaller and easier to displace than the actual size of prototype gabions (99 ft by 6 ft by 1 ft) that will be also wired or tied together. Therefore, it is considered that the stability indicated by the model is conservative.

Test Data

11. The hydraulic characteristics of each type of outlet modification were determined during the tests. Water-surface elevations measured 185 ft upstream of the crest were similar for all types and are shown in Plate 6. Discharge coefficients applicable to the broad-crested weir equation determined from these data are shown in Plate 7.

Discussion and Conclusions

12. The Type 5 outlet modification was the best design tested. The model tests demonstrated the importance of quality construction to ensure proper placement and tying together of the gabions, as irregular surfaces tend to cause failure of the structure. The gradation and size of stone placed in the gabion baskets should be uniform and large enough to prevent individual pieces from being washed through the wire mesh. Sufficient bedding and filter material should be placed between the soil foundation and the gabions to provide adequate subsurface drainage without leaching of the soil or the bedding and filter materials through the relatively thin mattress type of protection. The stability of the gabions may be improved by increasing the thickness and length of the gabions. However, it is considered that the larger, interconnected gabions planned for the proposed structure will be stable under all expected conditions.

13. Although the size and mesh of the aluminum wire screen used to construct the model gabions is considered significantly different from that of the prototype, the relatively greater flexibility of the

prototype gabion baskets allows for increased interlocking with adjacent baskets and for easier settling into areas such as the downstream toe of the structure should scour occur. Unknown factors include the durability and the duration that the wire mesh can resist weathering, abrasion, acts of vandalism, etc. However, gabion constructed channel control structures designed by the U. S. Army Engineer District, St. Paul (NCS), Office have performed satisfactorily for a number of years in the Souris River above Minot, N. Dak. Personnel of the U. S. Army Engineer District, New Orleans, visited and discussed these structures with personnel of NCS to make full use of the design principles and the satisfactory experiences gained to date.

Photo 1. Outlet modifications, Type 5 design

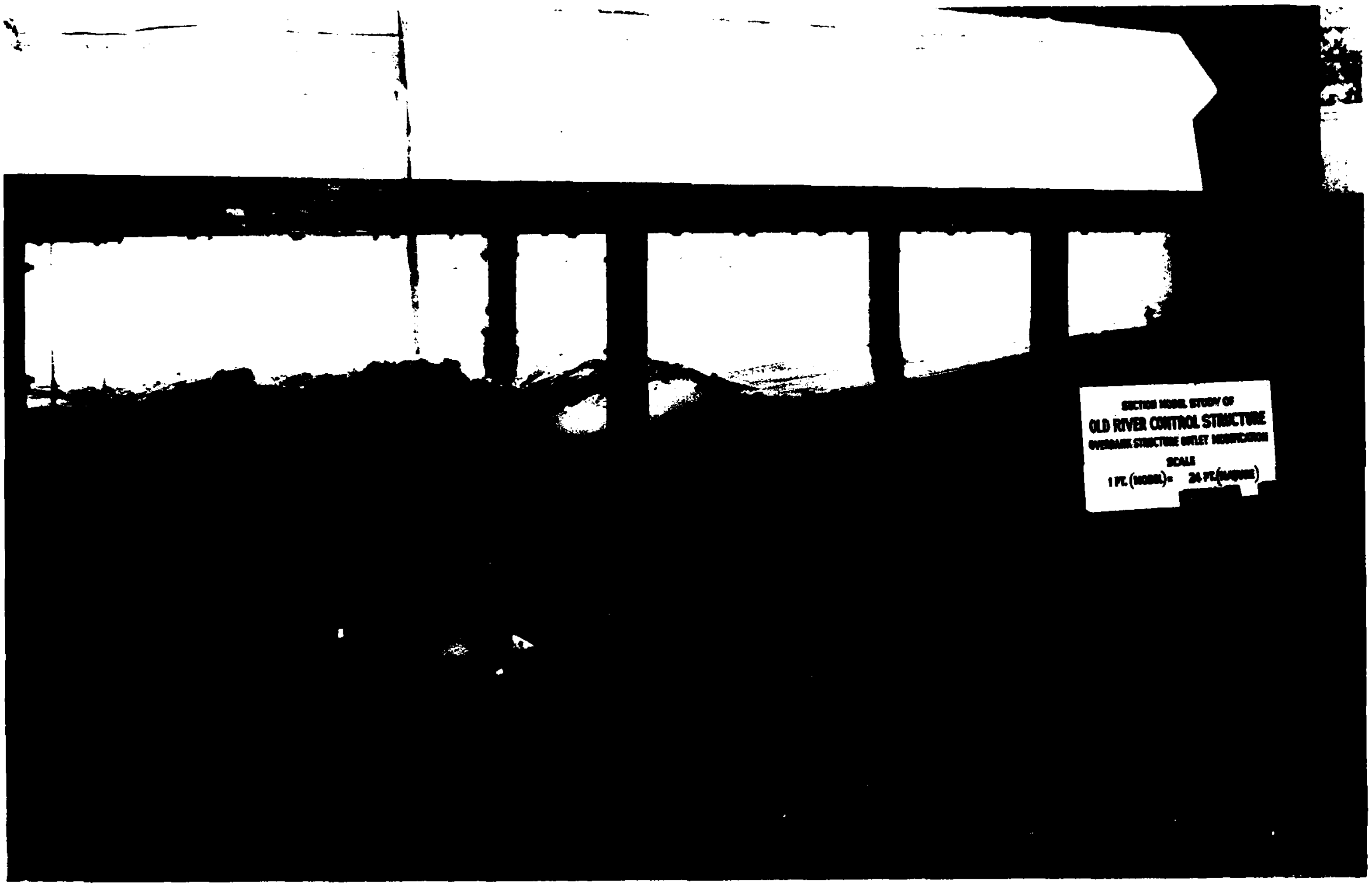


Photo 2. Flow conditions, Type 5 design (Q = 550,000 cfs; T. W. = 47.5 ft)

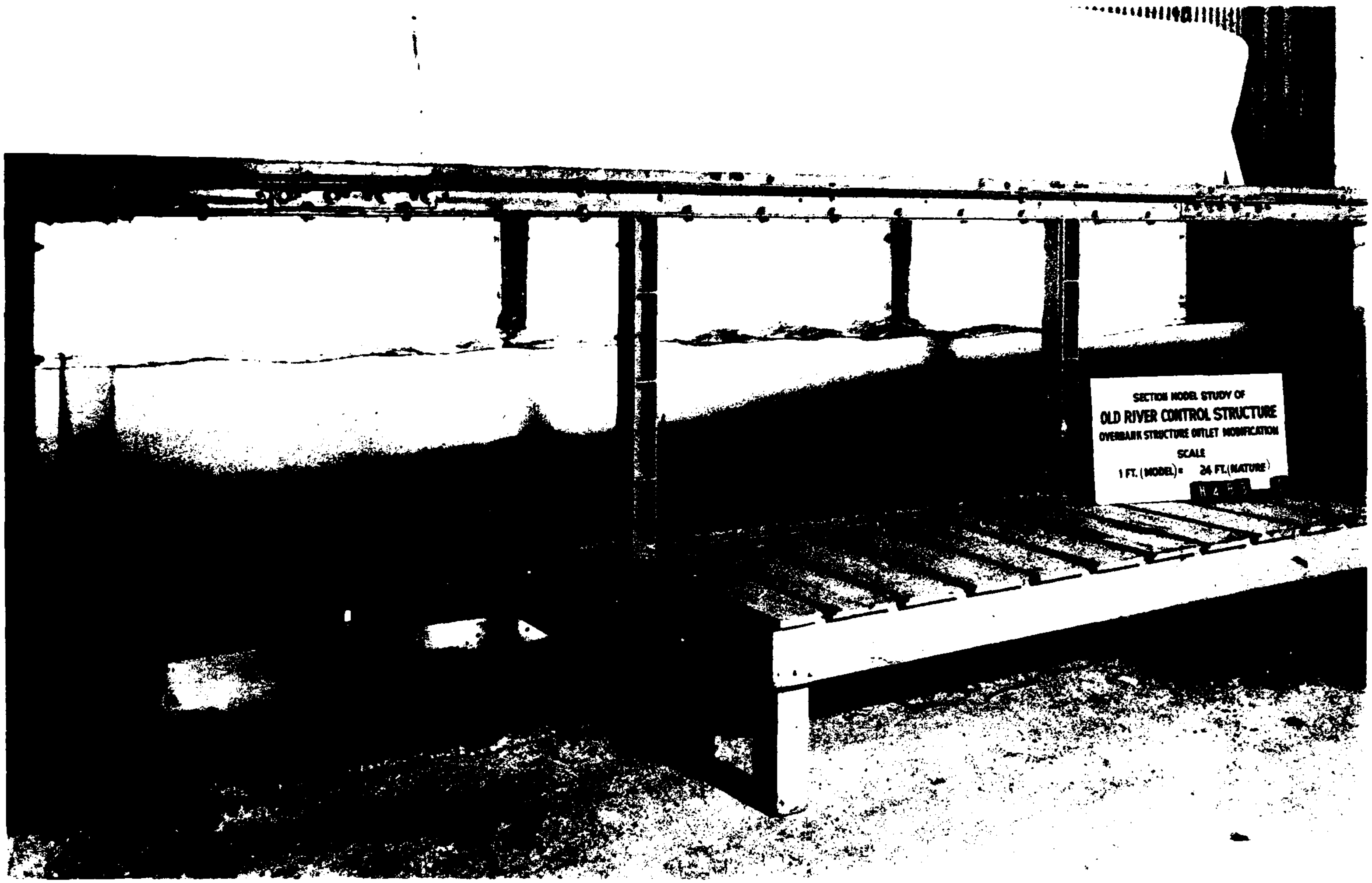


Photo 3. Flow conditions, Type 5 design (Q = 320,000 cfs; T. W. = 50.7 ft)

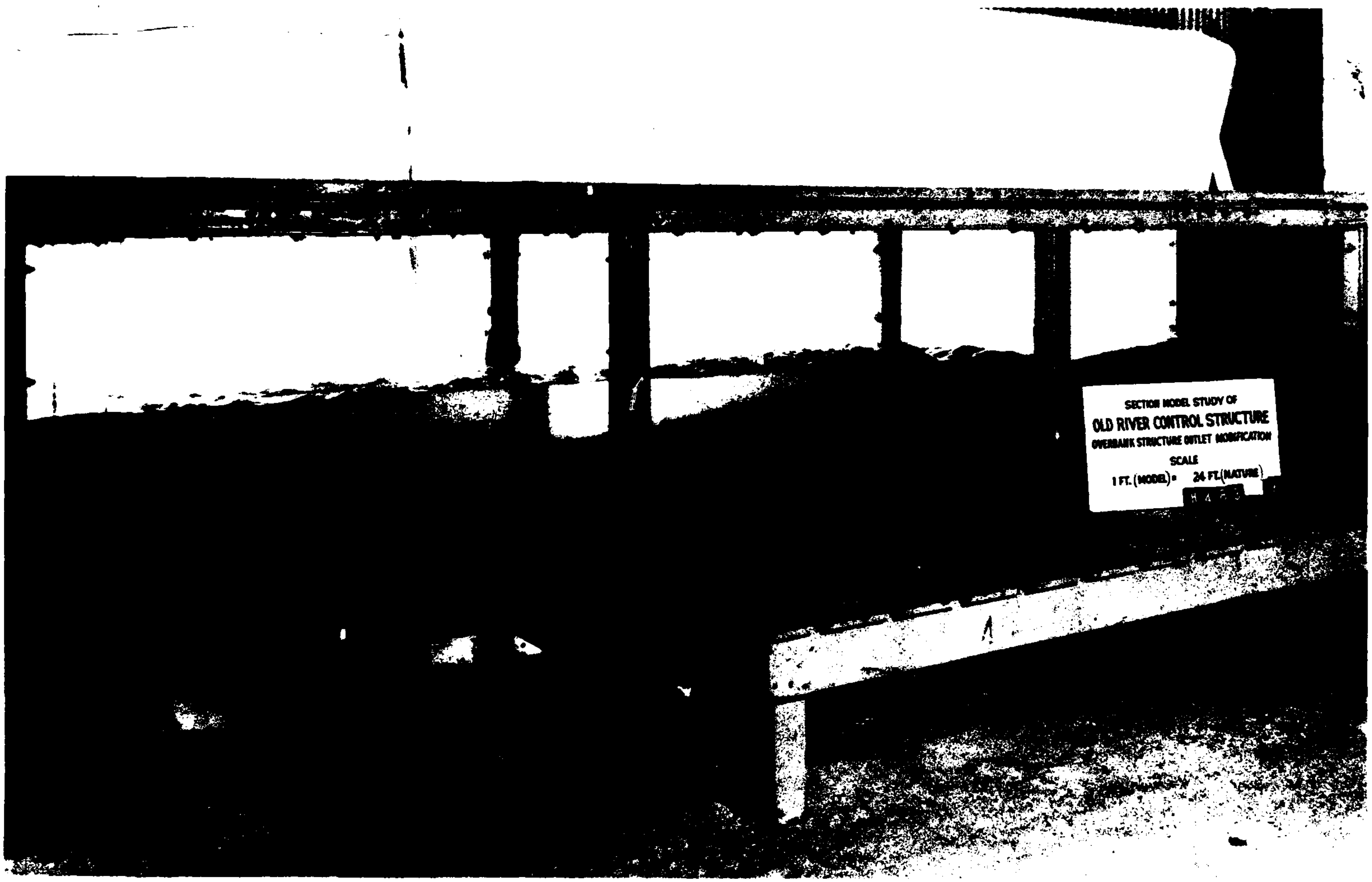


Photo 4. Flow conditions, Type 5 design (Q = 258,000 cfs; T. W. = 46.1 ft)

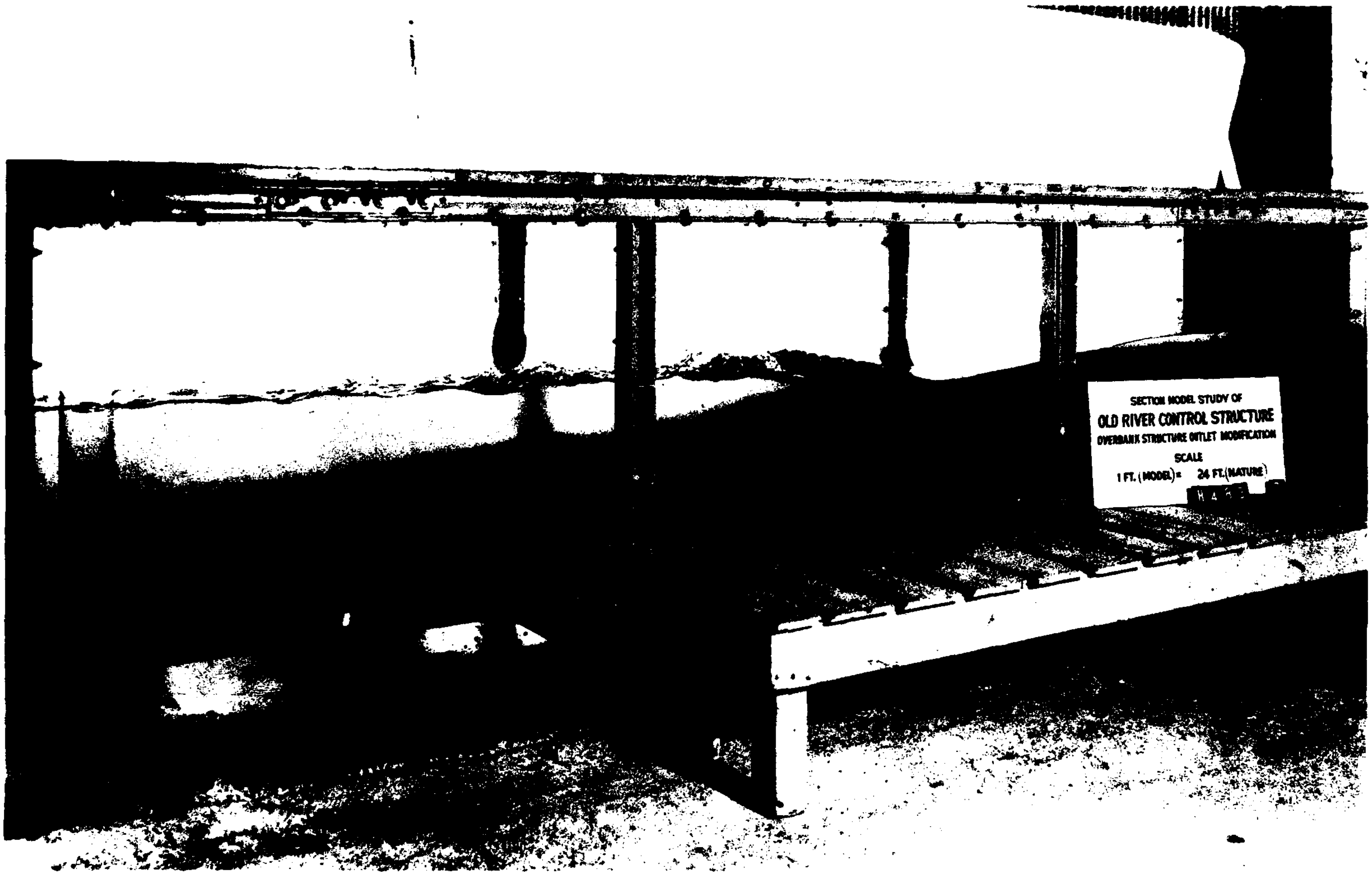


Photo 5. Flow conditions, Type 5 design (Q = 230,000 cfs; T. W. = 42.2 ft)

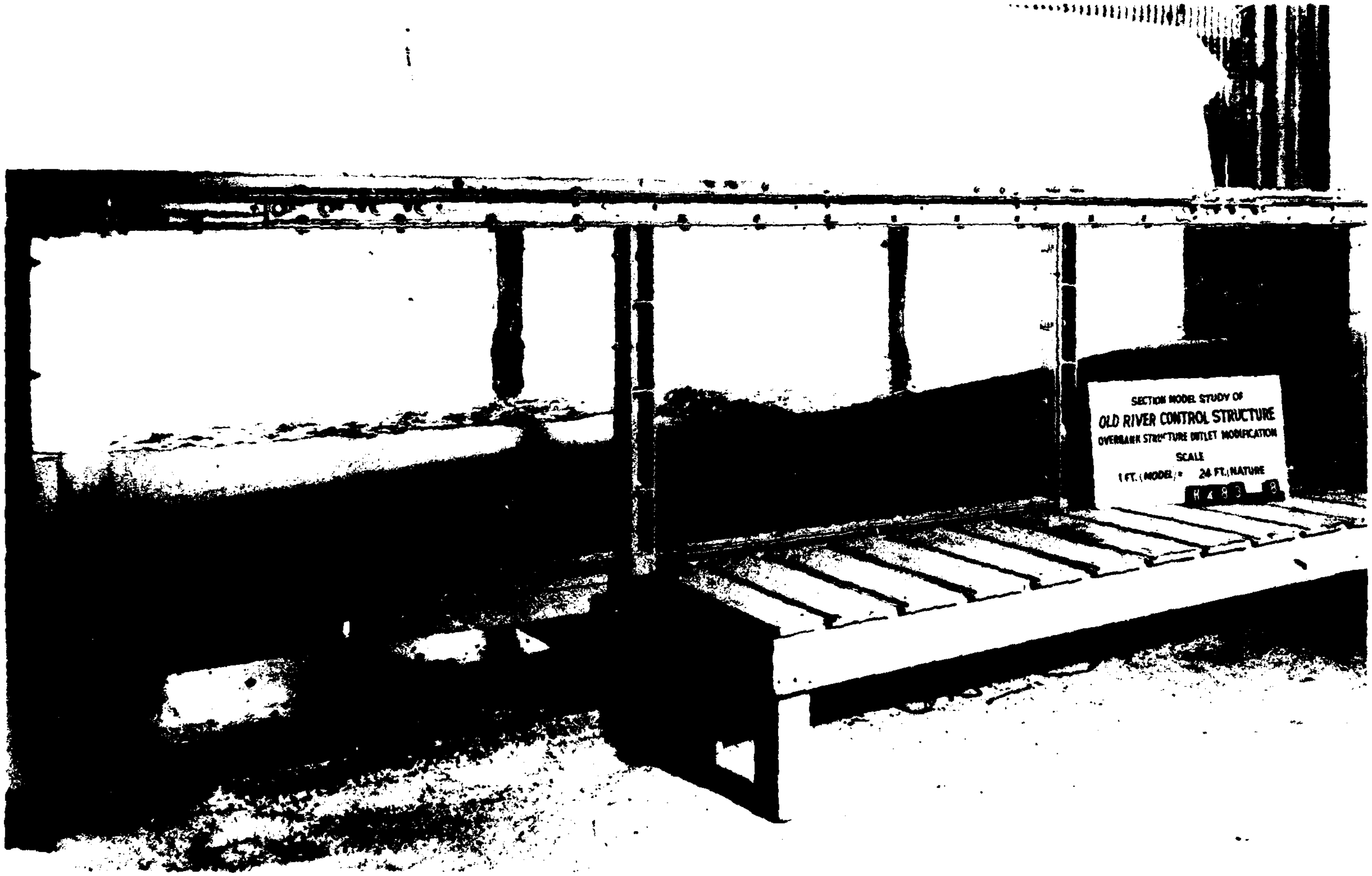
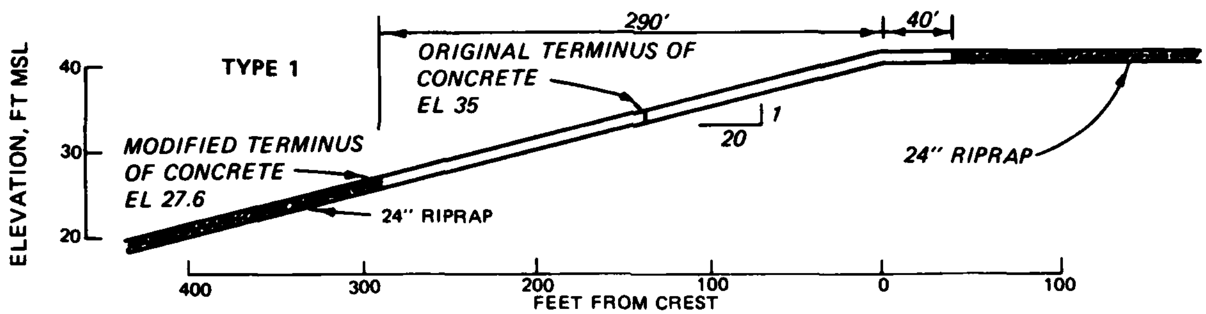


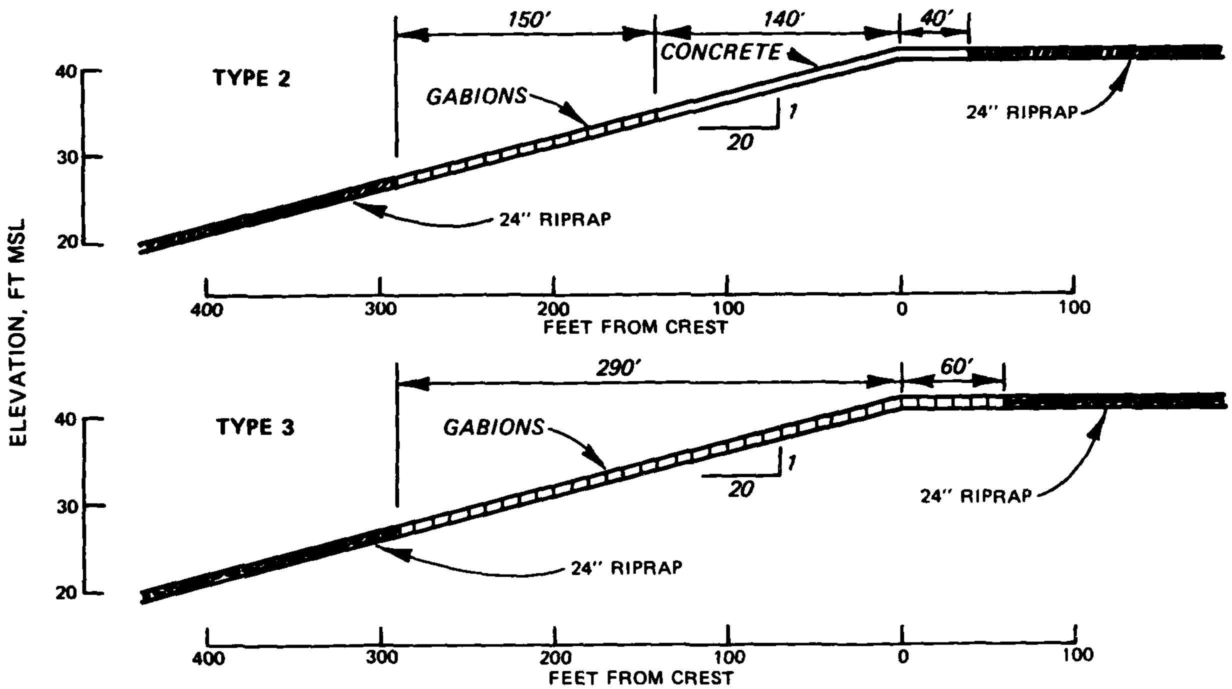
Photo 6. Flow conditions, Type 5 design (Q = 122,000 cfs; T. W. = 37.8 ft)

Photo 7. Flow conditions, Type 5 design (Q = 42,000 cfs; T. W. = 33.6 ft)

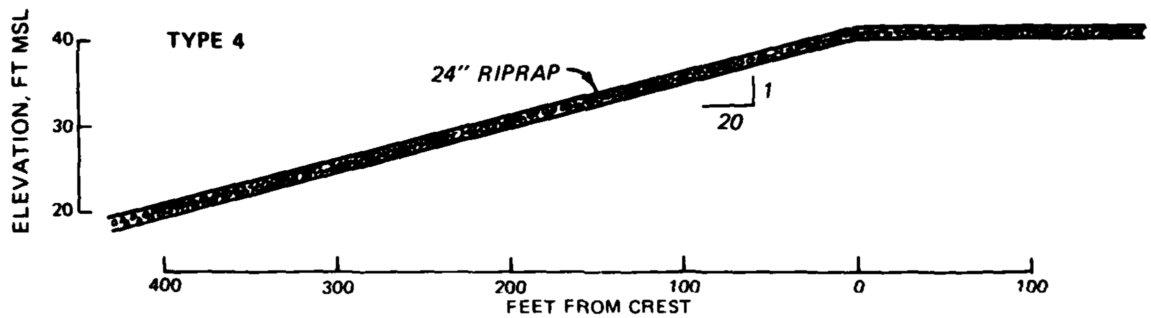
Photo 8. Failure of Type 6 design at Q = 550,000 cfs



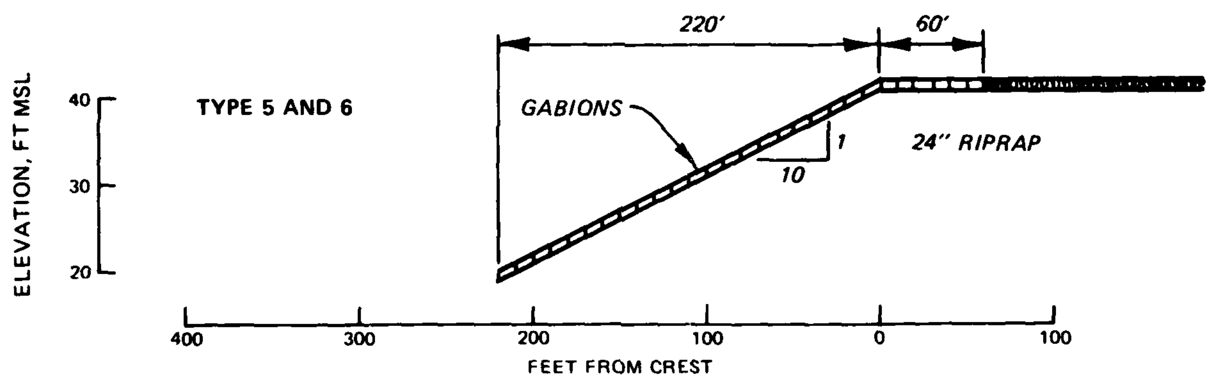
OLD RIVER OVERBANK STRUCTURE
OUTLET MODIFICATIONS
TYPE 1



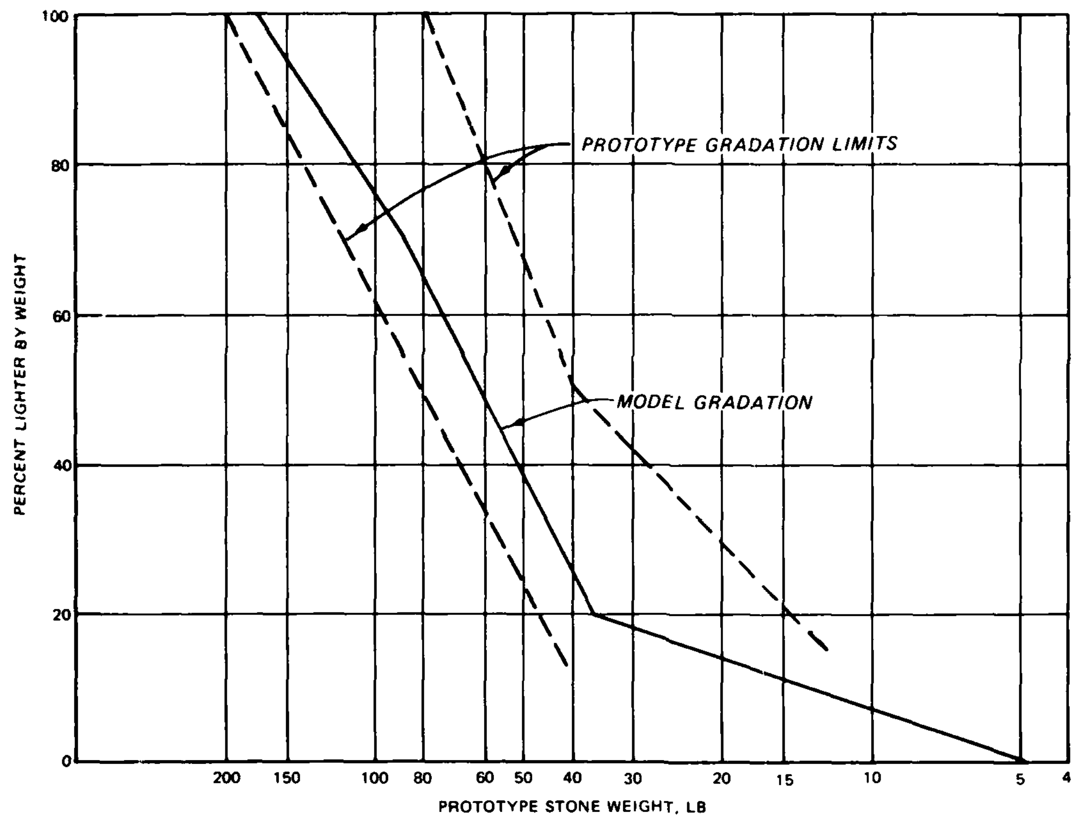
OLD RIVER OVERBANK STRUCTURE
OUTLET MODIFICATIONS
TYPES 2 AND 3



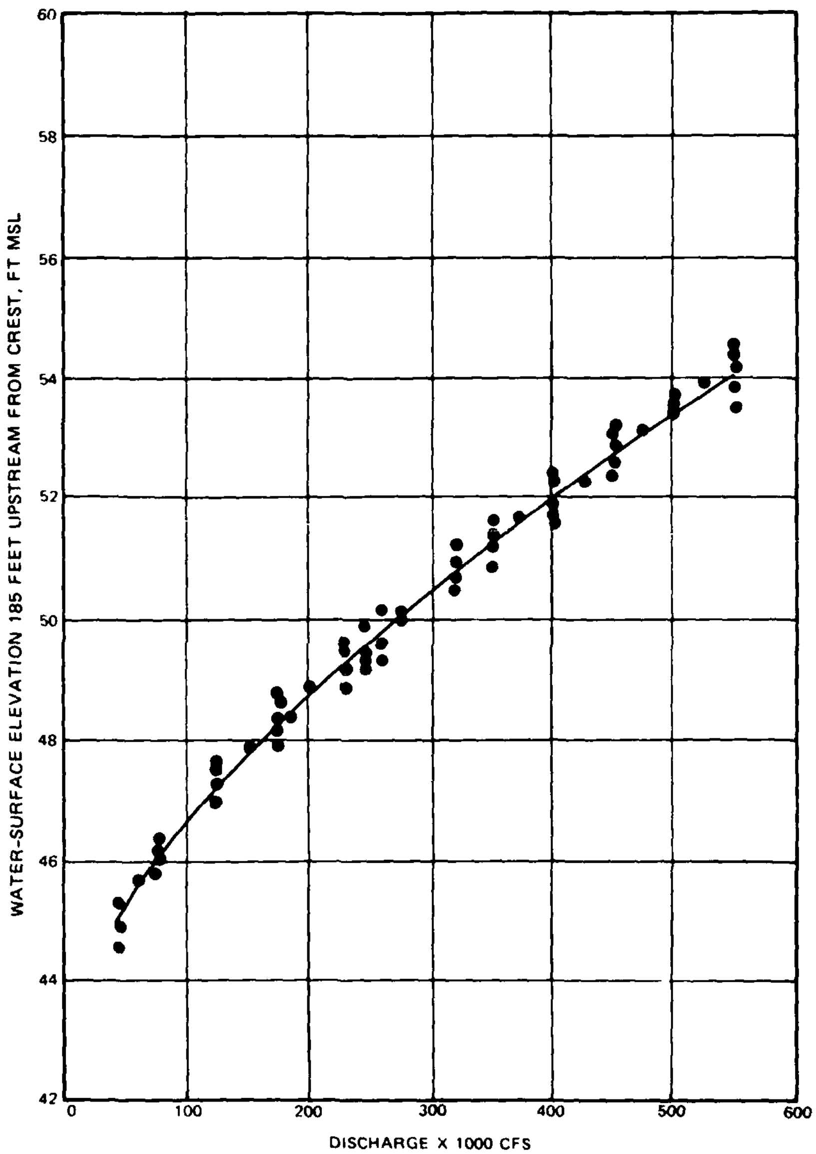
OLD RIVER OVERBANK STRUCTURE
OUTLET MODIFICATIONS
TYPE 4



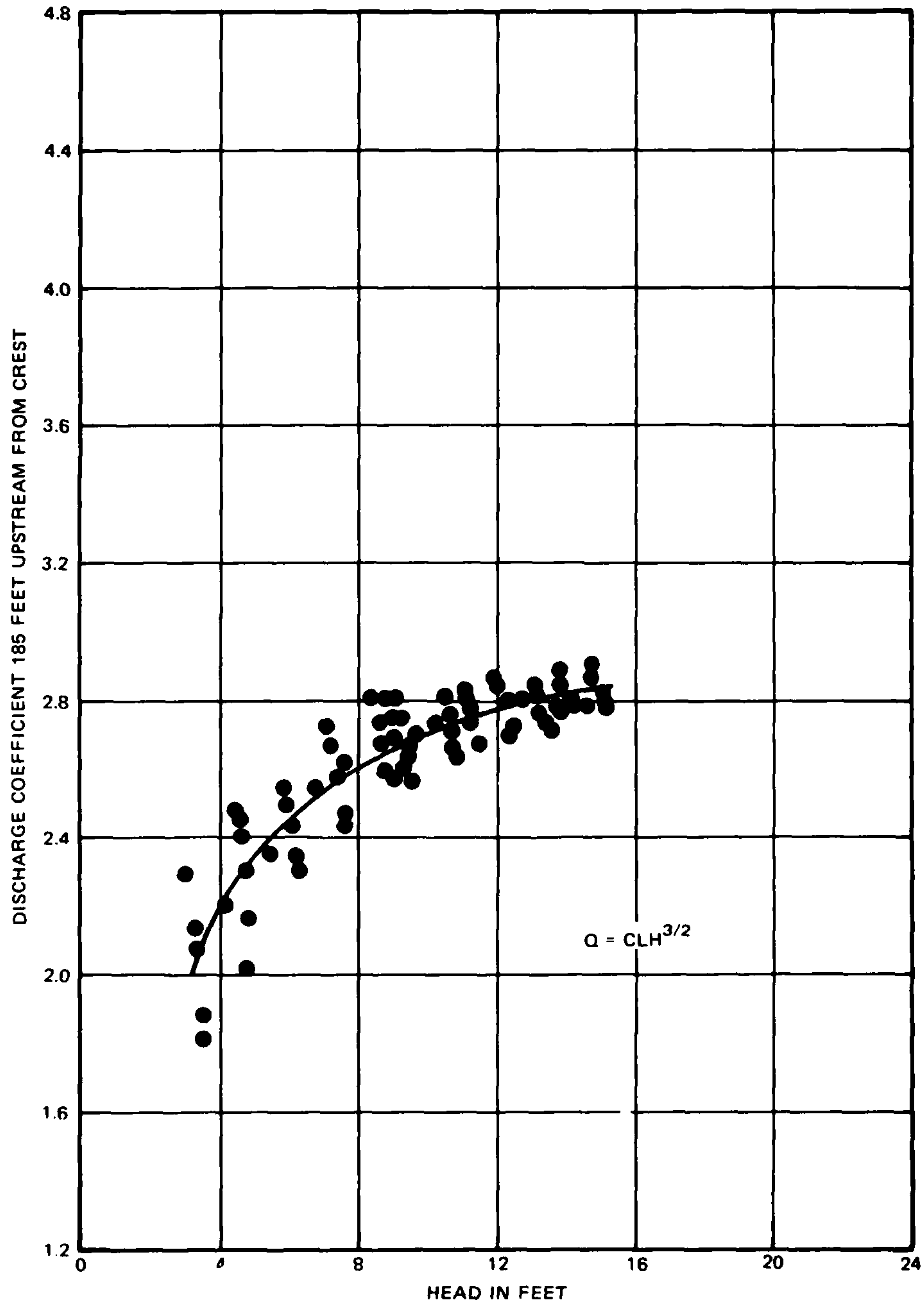
OLD RIVER OVERBANK STRUCTURE
OUTLET MODIFICATIONS
TYPES 5 AND 6



RIPRAP GRADATION



WATER-SURFACE ELEVATIONS



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